Hydroclimatic Reconstructions from Tree Rings for the Wasatch Front

Matt Bekker, Brigham Young University
Justin DeRose, US Forest Service
Tammy Rittenour, Utah State University

Wasatch Water Management Workshop, October 2, 2013

CIRES
Cooperative Institute for Research in Environmental Sciences

Rocky Mountain Research Station

WAsatch Dendroclimatology Research (WADR) Group

Brigham Young University Geography

Brigham Young University Founded BYU 1875 Provo, Utah

UtahState University
PLANTS, SOILS & CLIMATE

LAMONT-DOHERTY EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

Western Water Assessment

UtahState UNIVERSITY

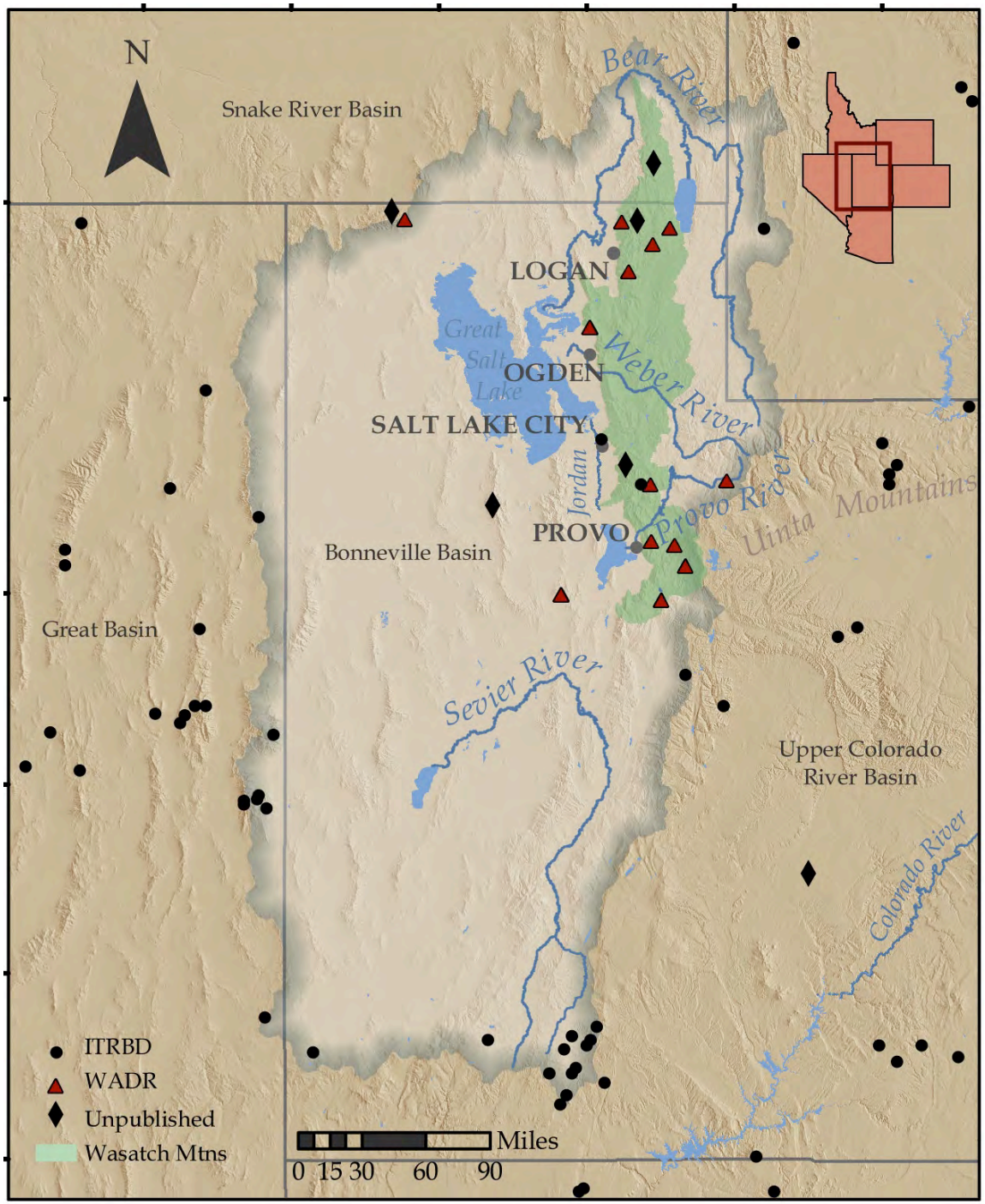
Forest Service U S Department of Agriculture

UTAH CLIMATE CENTER

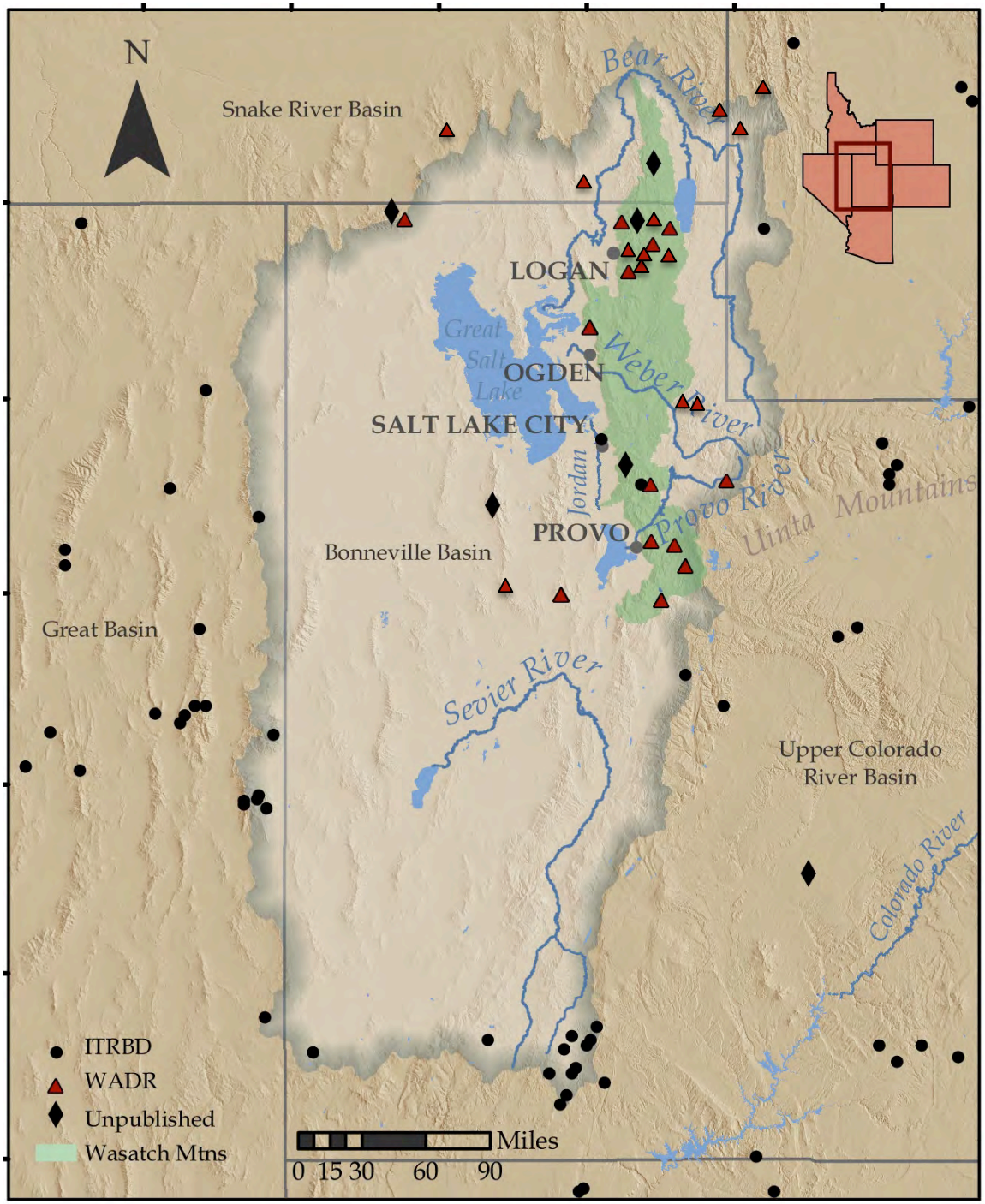
University of Colorado Boulder

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

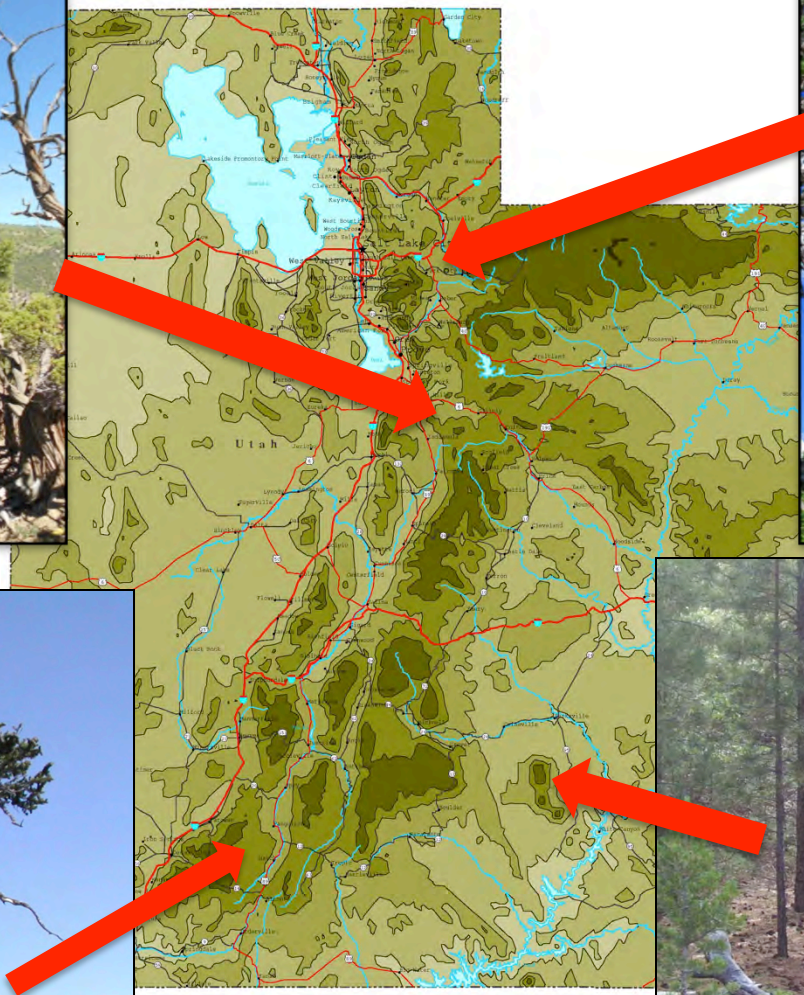
WADR tree-ring collection efforts



WADR tree-ring collection efforts



Yes, we have old trees in Utah!



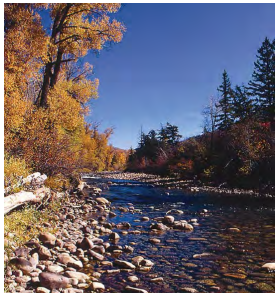
Outline – WADR reconstructions

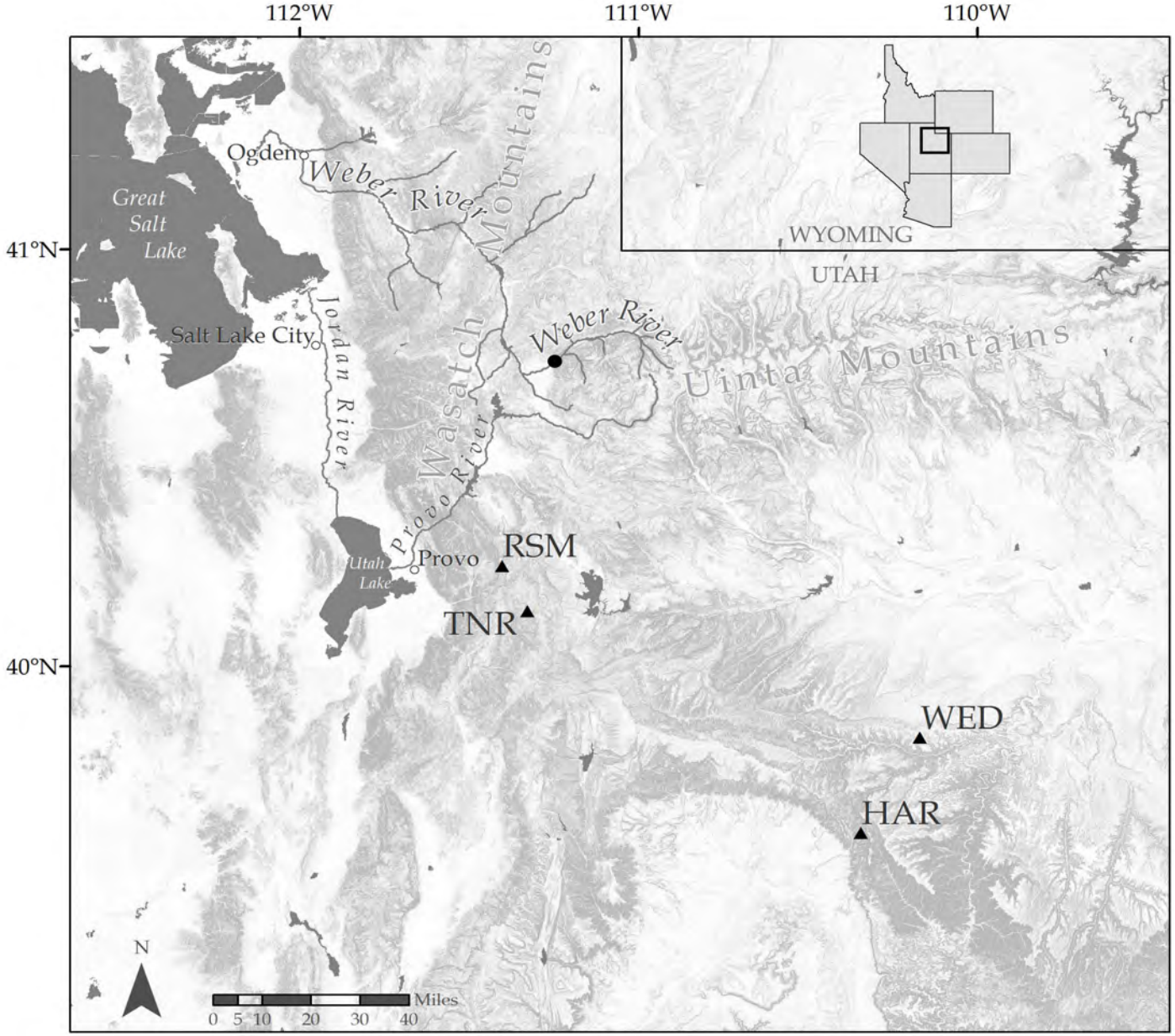
- Weber River – Matt Bekker

Great Salt Lake – Justin DeRose -

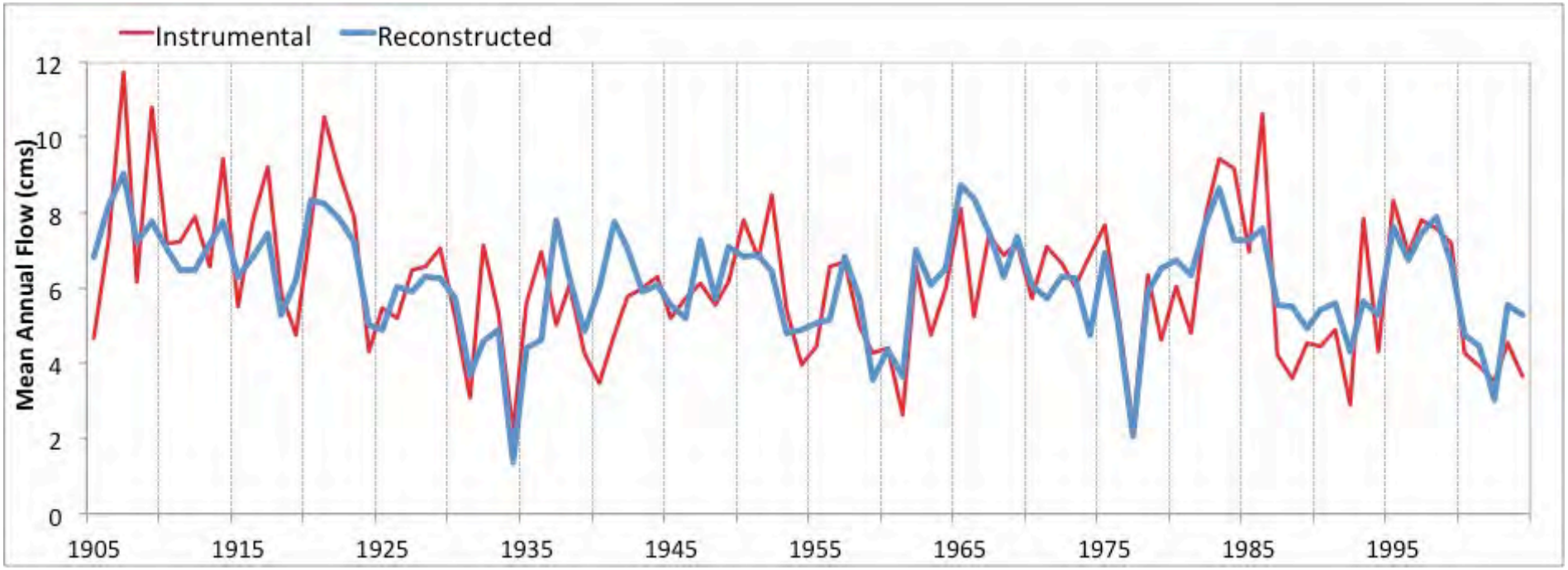
- Logan River – Tammy Rittenour

The Weber River

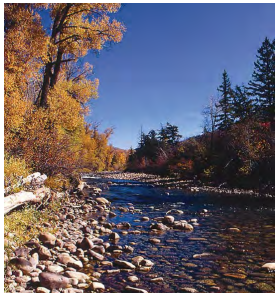


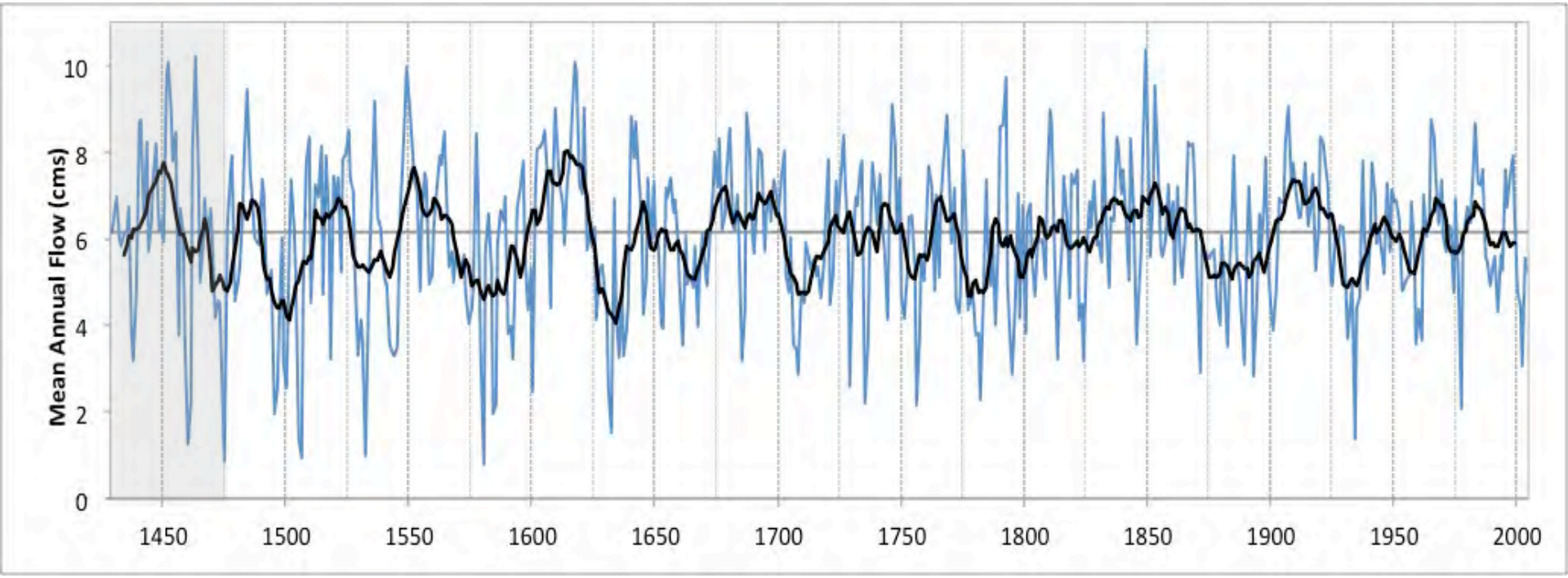


Weber River calibration & verification

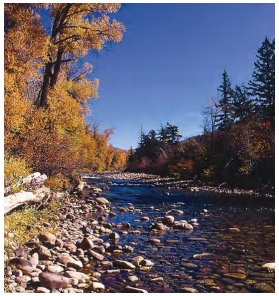


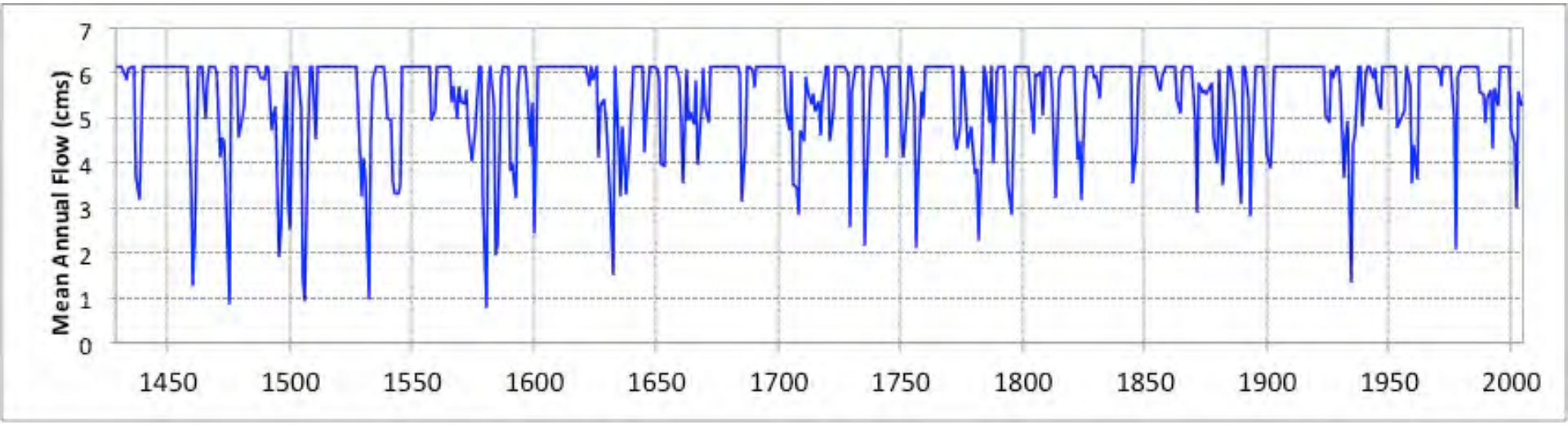
Weber River reconstruction





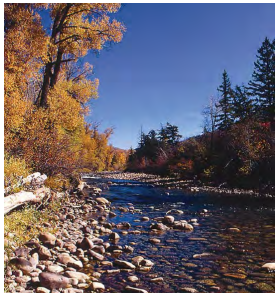
Persistent drought on the Weber

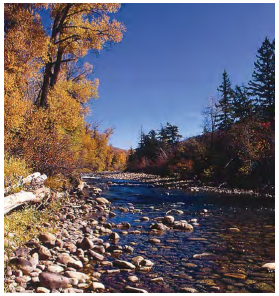




Most extreme individual years

Rank	Dry years	Wet years
1	1580	1849
2	1475	1463
3	1506	1617
4	1532	1452
5	1460	1549
6	**1934**	1618
7	1505	1451
8	1632	1792
9	1495	1853
10	1584	1484
11	**1977**	1536
12	1474	1746
13	1756	1550
14	1585	**1907**
15	1735	1609
16	1461	1621
17	1782	1810
18	1600	1548
19	1496	1453
20	1500	1687
21	1631	1832
22	1729	1768
23	1893	1640
24	1708	1616
25	1795	**1965**
26	1871	1441
27	**2002**	1642
28	1499	1440
29	1889	1811





Extreme dry periods

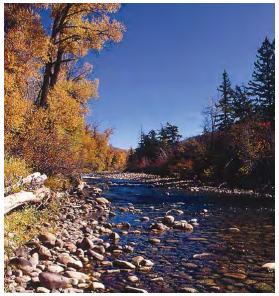
Period	Duration (yrs)	Magnitude (cms)	Intensity (cms/yr)	Score
Dry				
1492-1500	9	-20.22	-2.25	110
1470-1475	6	-14.61	-2.44	109
1528-1534	7	-15.33	-2.19	106
1504-1507	4	-12.16	-3.04	106
1459-1461	3	-11.26	-3.75	105
1626-1632	7	-14.82	-2.12	102
1583-1586	4	-9.32	-2.33	99
1579-1581	3	-8.77	-2.92	99
1776-1783	8	-15.07	-1.88	98
1930-1936	7	-13.77	-1.97	98
1634-1639	6	-12.77	-2.13	98
1539-1545	7	-13.69	-1.96	96
1793-1796	4	-8.89	-2.22	94
1735-1737	3	-7.08	-2.36	92
1590-1593	4	-7.99	-2.00	88
1437-1439	3	-6.87	-2.29	88
1703-1718	16	-20.58	-1.29	86
1755-1759	5	-9.01	-1.80	84
1958-1961	4	-7.28	-1.82	81
1822-1825	4	-7.27	-1.82	79
1870-1883	14	-16.35	-1.17	78
1892-1894	3	-5.85	-1.95	71
2000-2004	5	-7.70	-1.54	72
1597-1600	4	-6.76	-1.69	72
1886-1889	4	-6.69	-1.67	70

Extreme dry “clusters”

Period	Magnitude (cms)	Intensity (cms/yr)	Duration (yrs)	Yrs > mean	Score
Dry					
1626-1639	-26.80	-1.91	14	1	20
1622-1639	-27.41	-1.52	18	2	20
1579-1586	-17.66	-2.21	8	1	16
1772-1783	-17.98	-1.50	12	1	15
1772-1789	-20.34	-1.13	18	3	11
1772-1786	-18.24	-1.22	15	2	11
1776-1789	-17.43	-1.24	14	2	10
1622-1632	-15.43	-1.40	11	1	10
1776-1786	-15.33	-1.39	11	1	10
1953-1961	-11.31	-1.26	9	1	7
1785-1789	-3.55	-0.71	5	1	2

Extreme wet periods

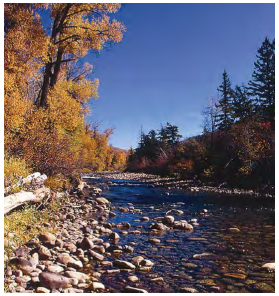
Period	Duration (yrs)	Magnitude (cms)	Intensity (cms/yr)	Score
Wet				
1451-1455	5	14.19	2.84	127
1614-1621	8	18.00	2.25	125
1790-1792	3	8.47	2.82	121
1546-1553	8	15.40	1.92	120
1601-1606	6	10.61	1.77	113
1462-1464	3	7.21	2.40	111
1640-1644	5	8.54	1.71	109
1440-1443	4	7.49	1.87	107
1848-1850	3	7.06	2.35	106
1523-1527	5	8.02	1.60	105
1866-1869	4	7.46	1.86	105
1482-1486	5	7.58	1.52	101
1809-1811	3	6.29	2.10	101
1852-1854	3	5.98	1.99	99
1687-1688	2	4.73	2.37	99
1560-1565	6	7.96	1.33	97
1608-1612	5	7.43	1.49	96
1766-1769	4	6.95	1.74	96
1964-1969	6	7.90	1.32	95
1903-1917	15	16.17	1.08	92
1919-1923	5	7.14	1.43	91
1979-1986	8	8.92	1.11	89
1508-1509	2	3.81	1.90	86
1673-1683	11	11.37	1.03	83
1691-1693	3	4.48	1.49	82

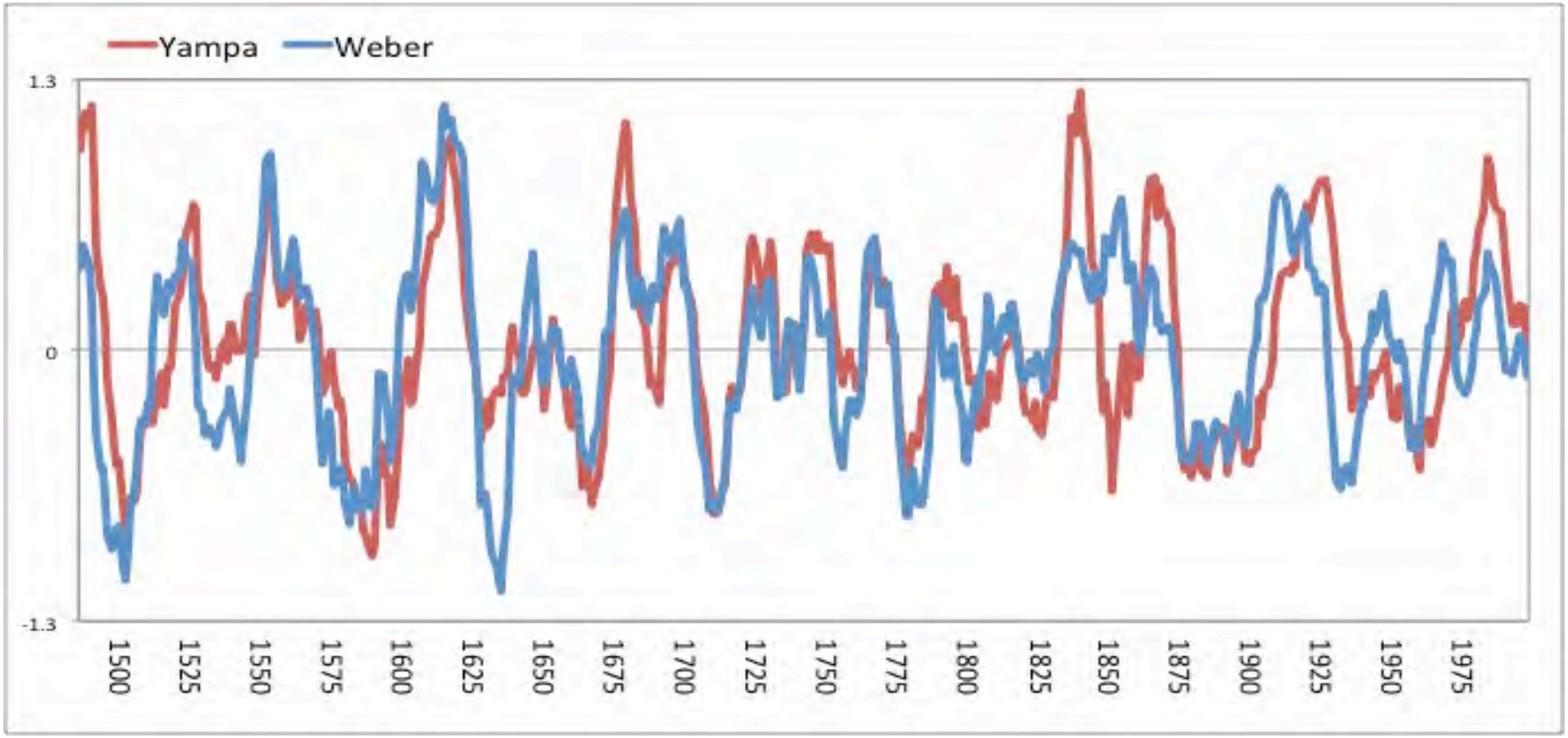


Period	Magnitude (cms)	Intensity (cms/yr)	Duration (yrs)	Yrs < mean	Score
Wet					
1608-1621	25.15	1.80	14	1	45
1601-1621	34.01	1.62	21	2	44
1440-1455	24.73	1.55	16	2	40
1445-1455	17.67	1.61	11	1	38
1848-1854	12.49	1.78	7	1	36
1440-1458	22.88	1.20	19	3	35
1546-1557	16.87	1.41	12	1	34
1601-1612	16.30	1.25	13	1	32
1451-1458	12.33	1.54	8	1	31
1903-1923	22.45	1.07	21	1	30
1445-1458	15.82	1.13	14	2	28
1440-1449	10.74	1.07	10	1	22
1519-1527	10.30	1.14	9	1	22
1691-1702	11.13	0.93	12	1	21
1512-1527	11.84	0.74	16	3	16
1832-1844	10.57	0.81	13	2	16
1832-1841	8.99	0.90	10	1	15
1516-1527	9.39	0.78	12	2	13
1835-1844	8.95	0.90	10	1	13
1512-1517	4.47	0.63	6	1	8
1512-1521	4.74	0.47	10	2	6
1816-1821	4.13	0.69	6	1	5
1516-1521	2.29	0.38	6	1	2

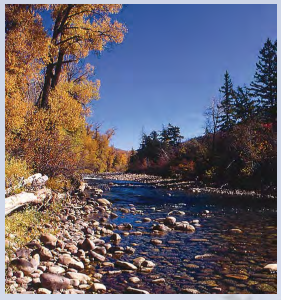
Extreme wet “clusters”

Weber vs. Yampa (UCRB)



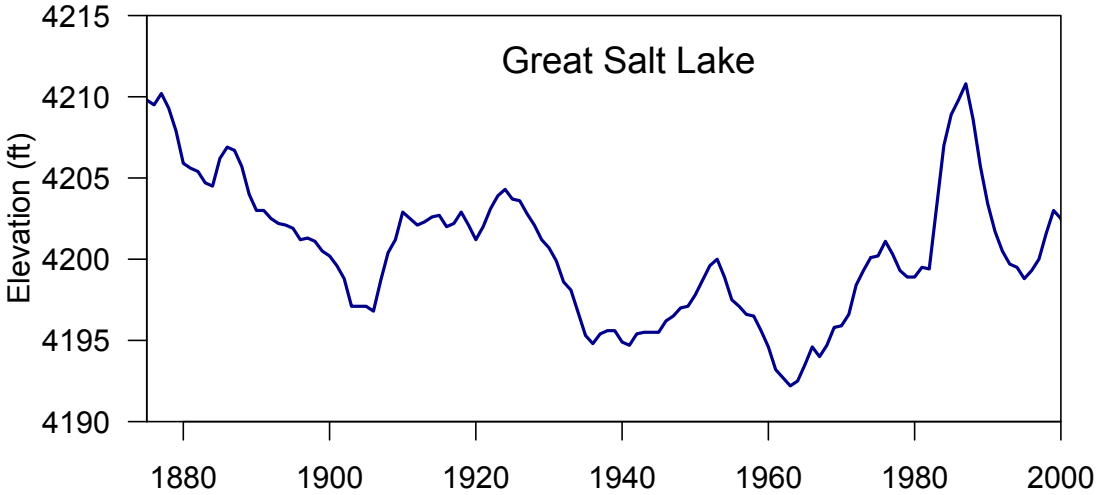


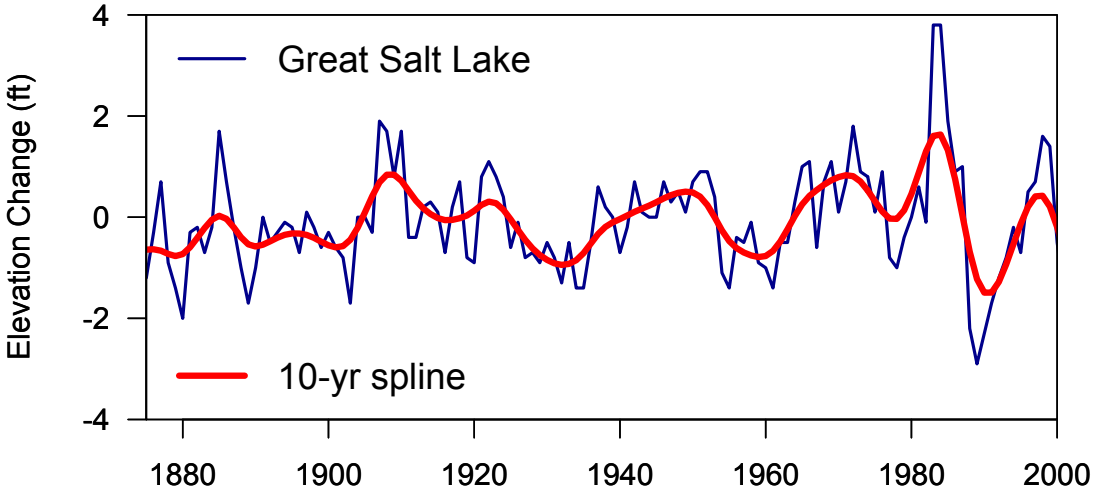
Conclusions



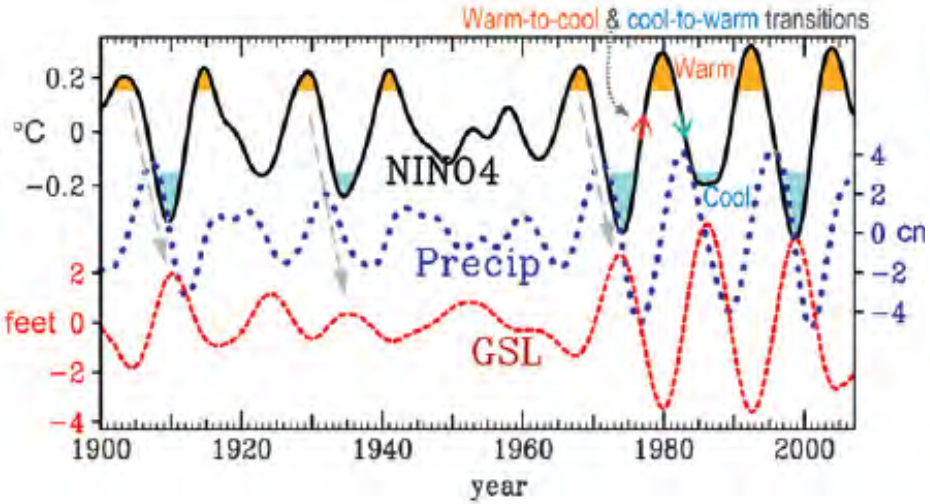
- Considerable variability at annual and decadal scales
- Droughts (and wet periods) in the instrumental record have been exceeded in magnitude, duration, and intensity by those in previous centuries
- Reconstructed extreme years and longer periods can be used as a basis for assessment of drought and flood risk

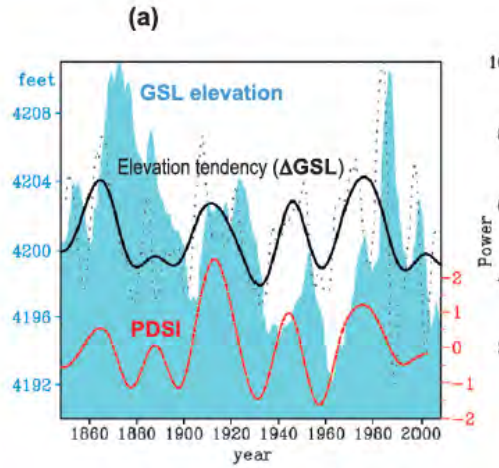
Great Salt Lake

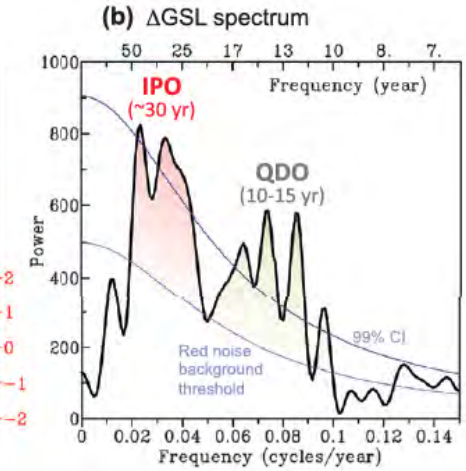


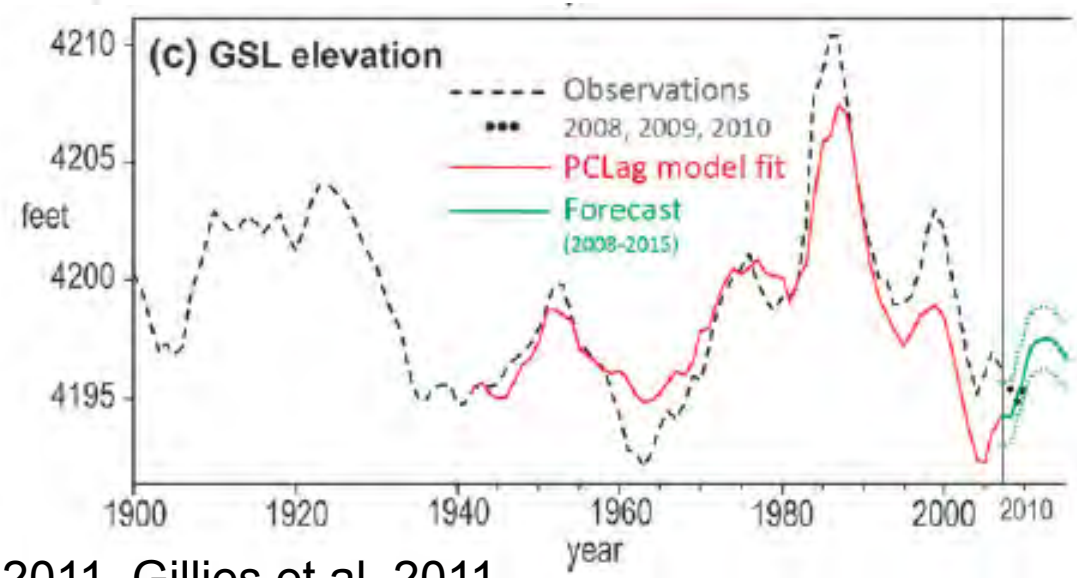


Historical Data



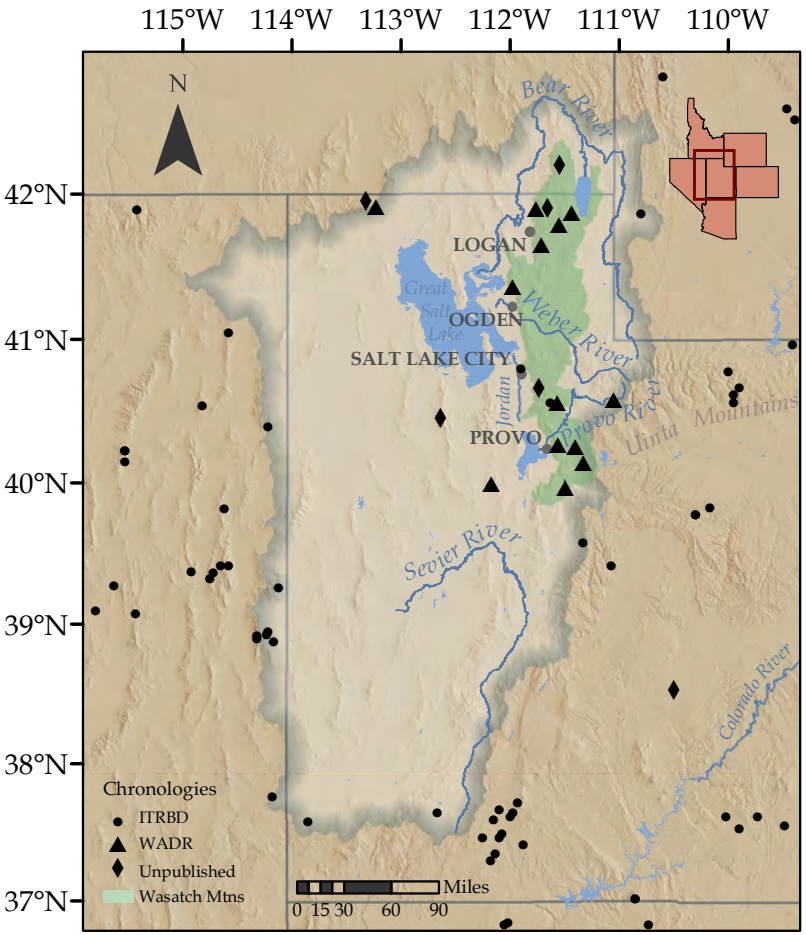


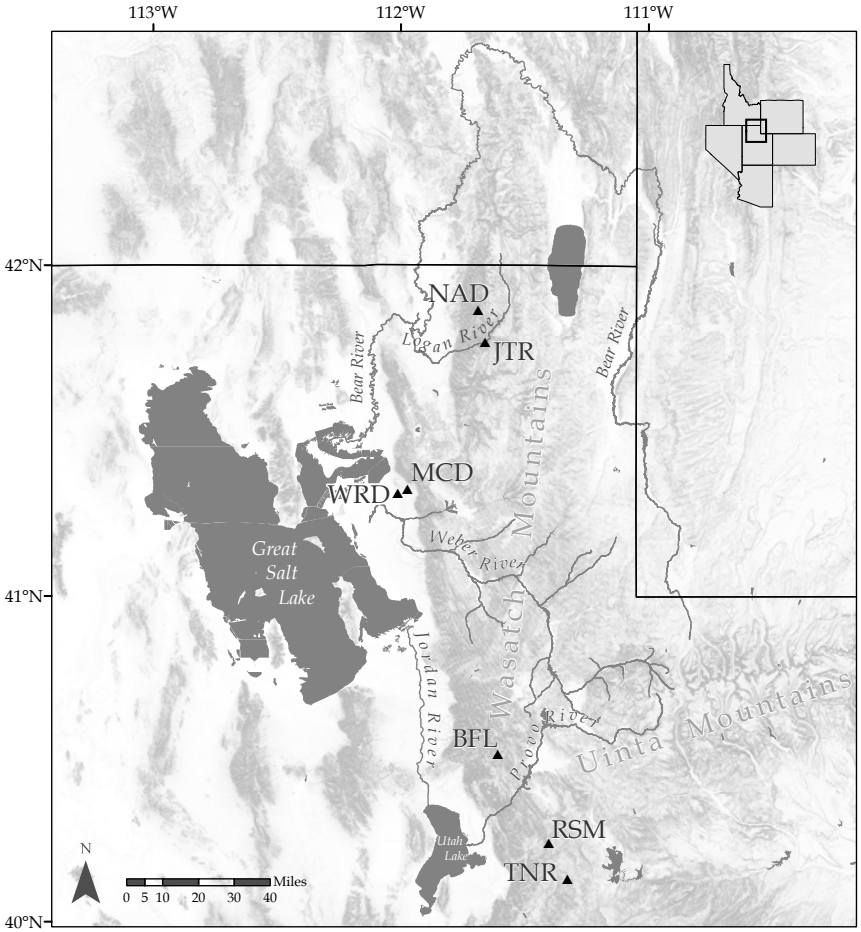




Wang et al. 2010, 2011, Gillies et al. 2011

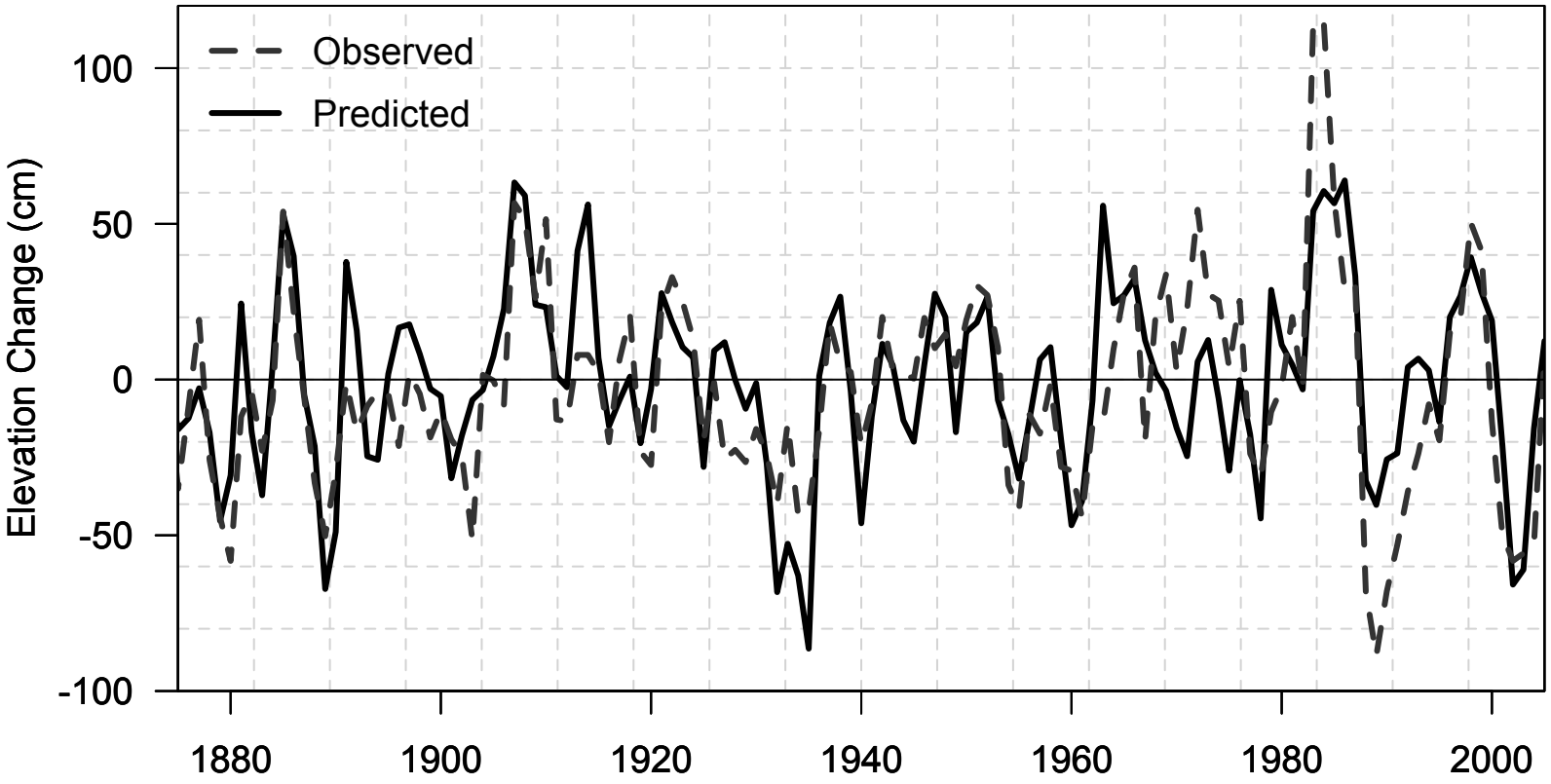
Tree-ring sites



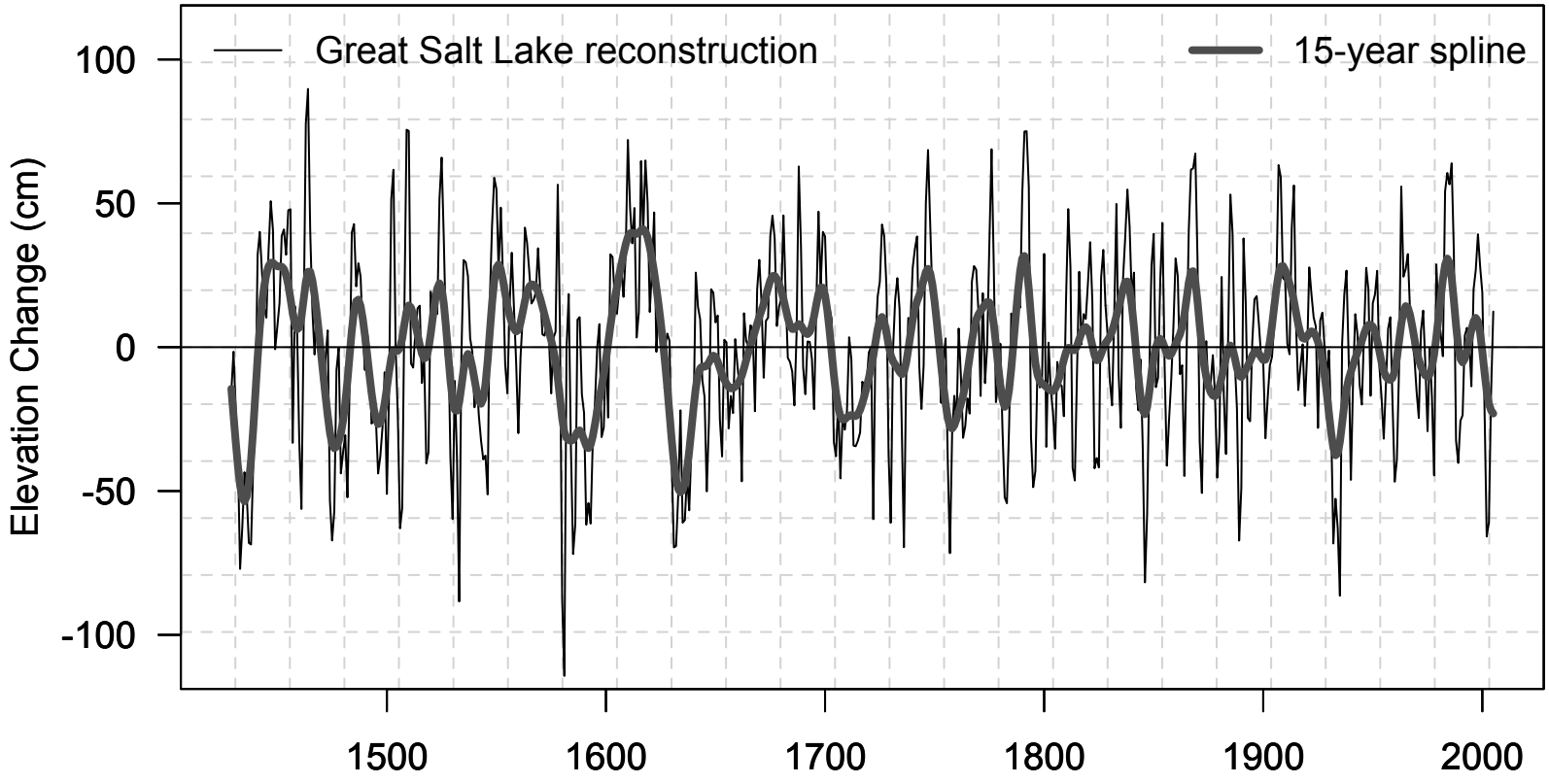


Model

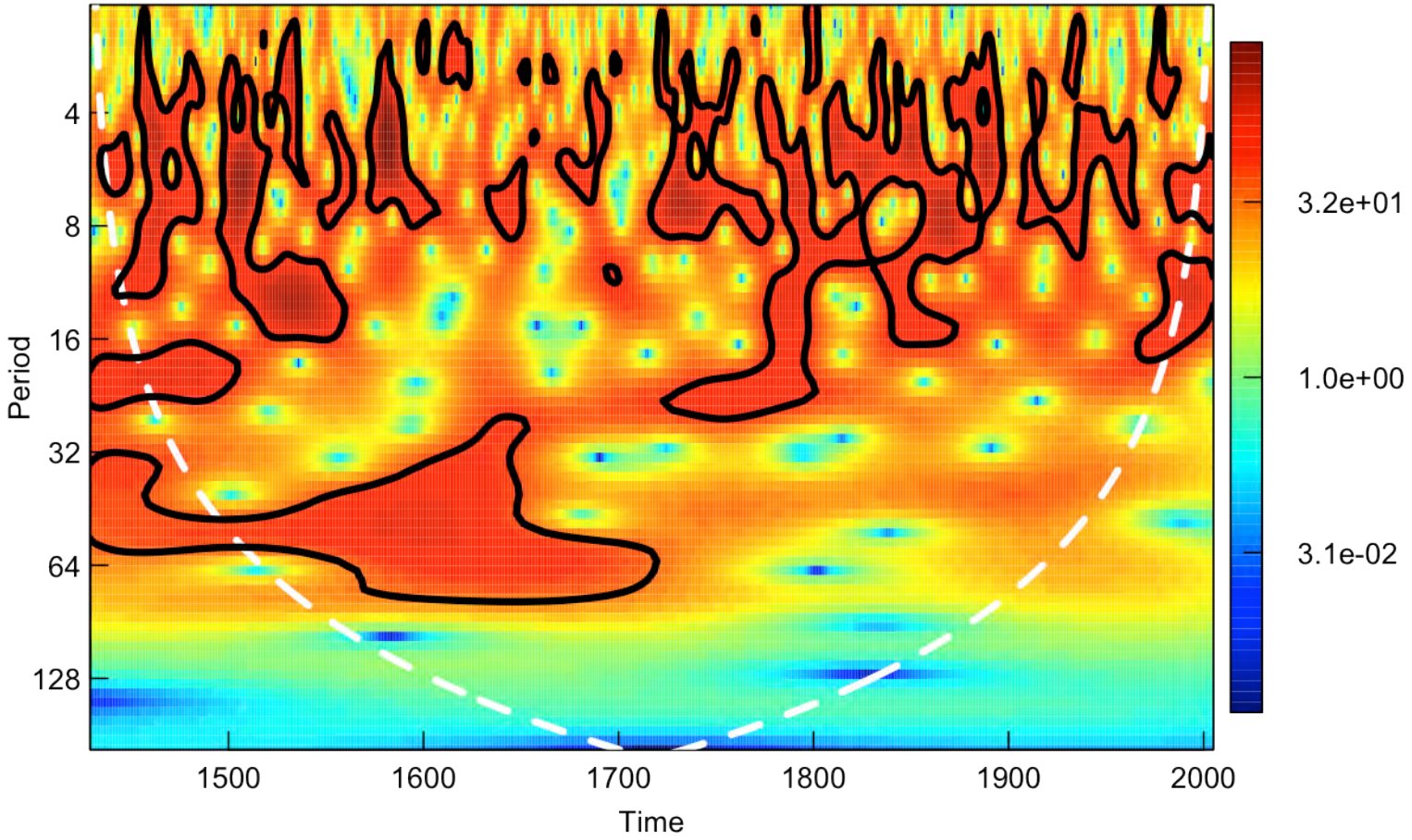
Great Salt Lake


Observed
Predicted
Elevation Change (cm)
100
50
0
-50
-100
1880
1900
1920
1940
1960
1980
2000

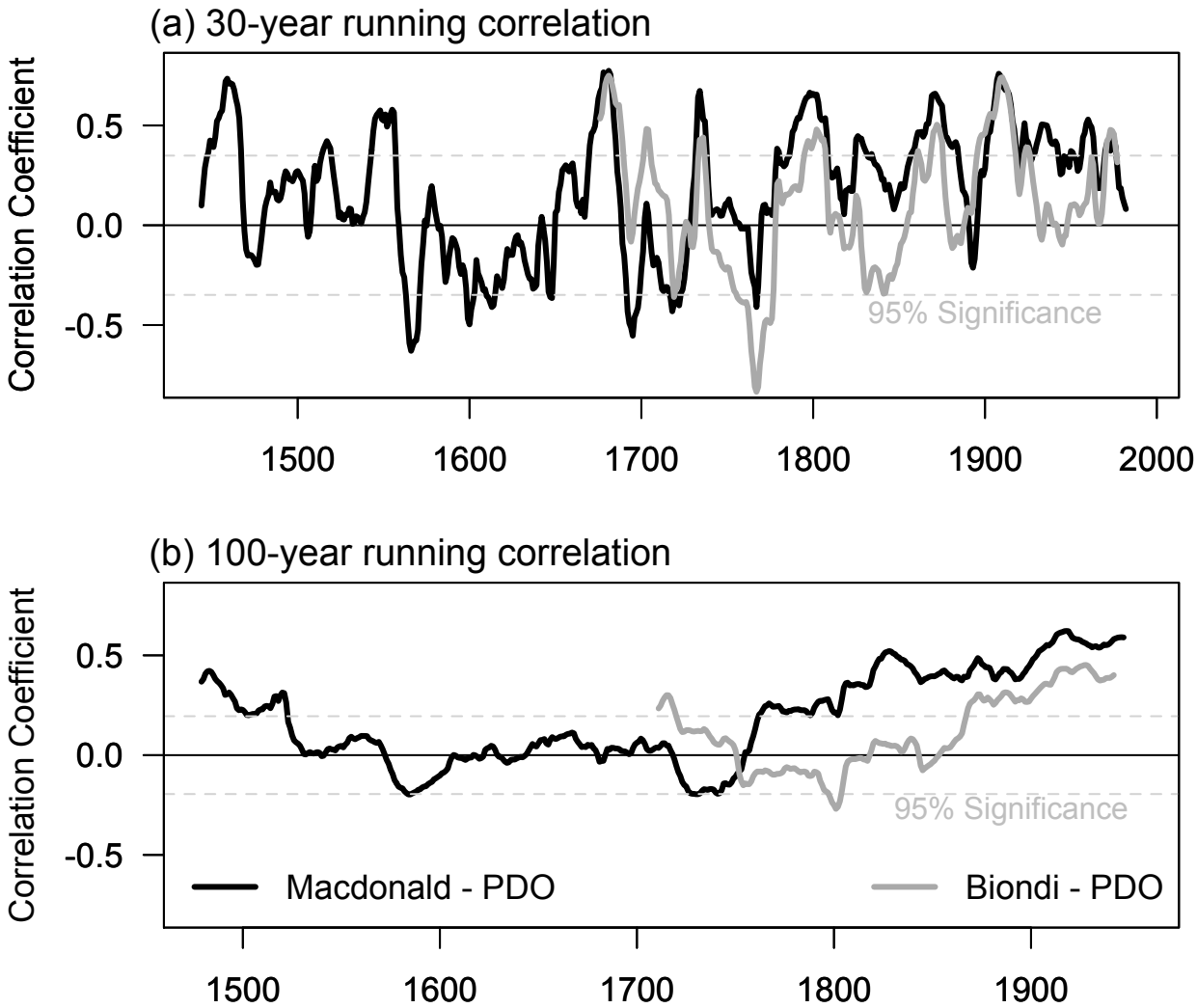
Reconstruction



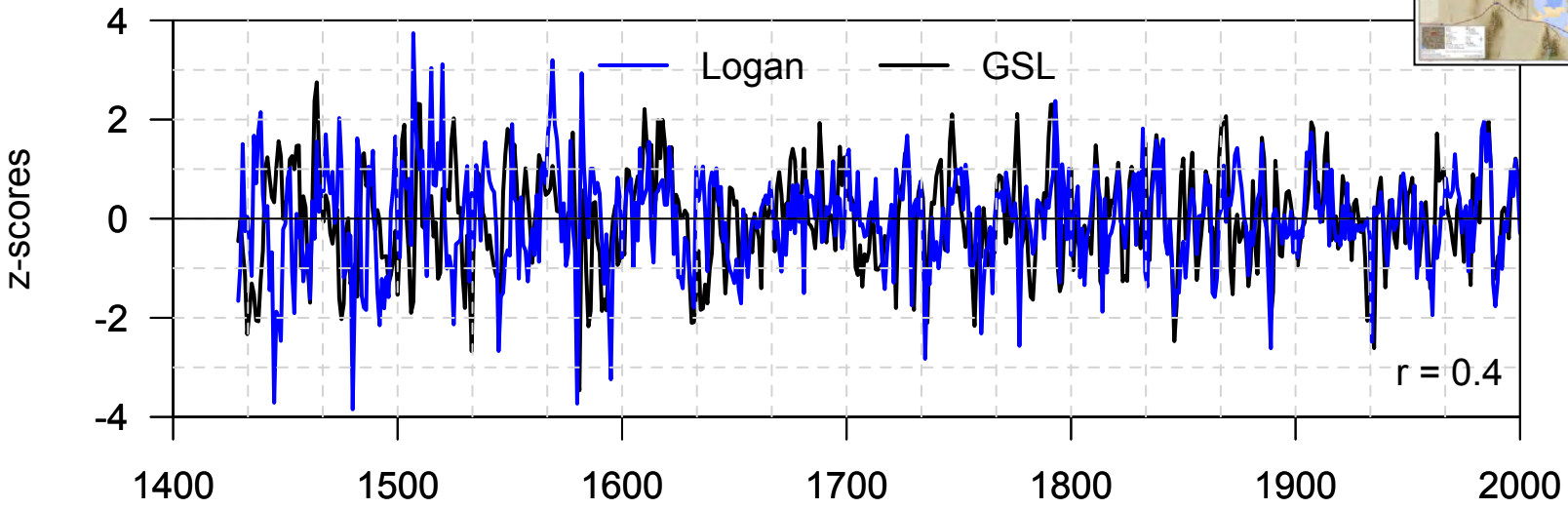
Periodicity

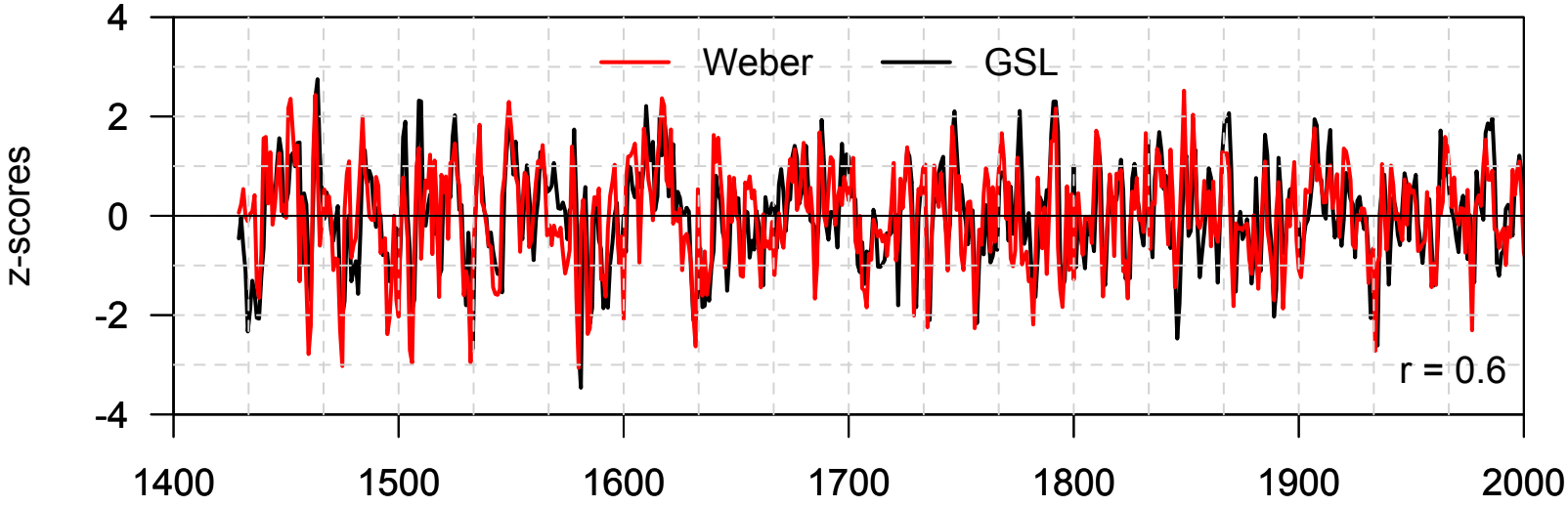


Climate Diagnostics

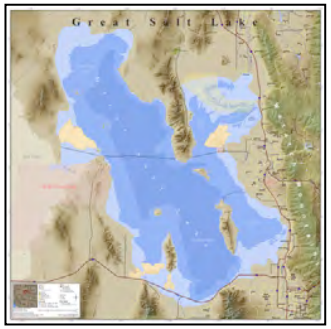


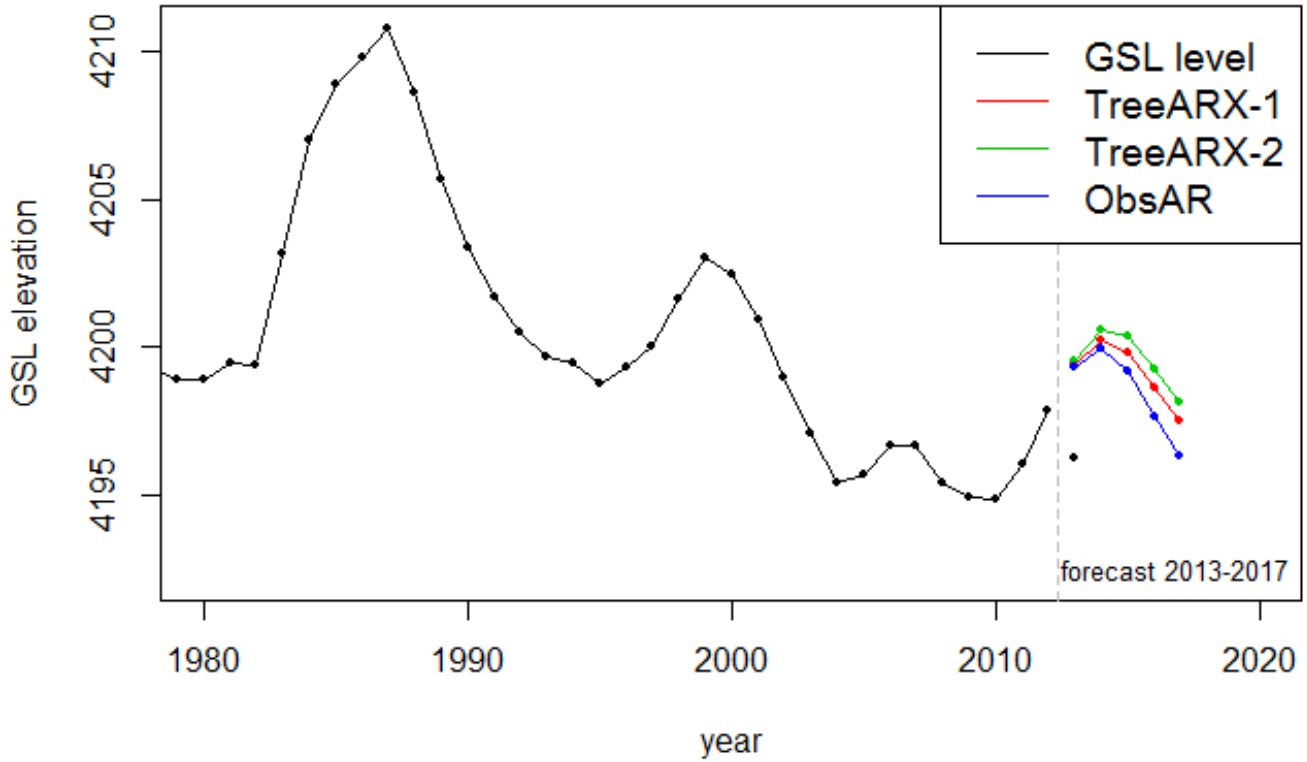
GSL vs Stream flow



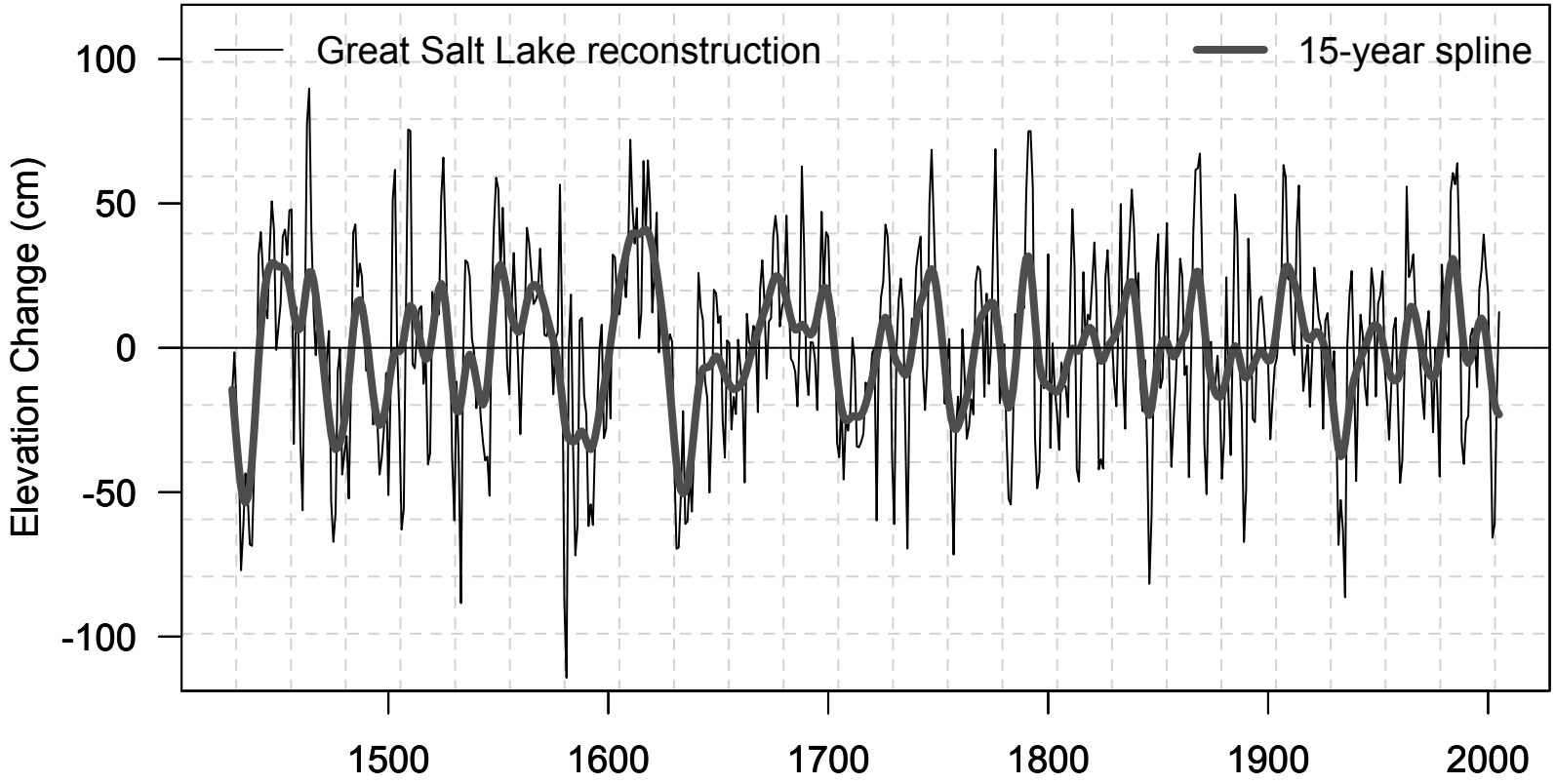


Prediction


Great Salt Lake


GSL level
TreeARX-1
TreeARX-2
ObsAR
forecast 2013-2017
GSL elevation
4195
4200
4205
4210
1980
1990
2000
2010
2020
year

Drought/Pluvials



Conclusions

Applications:

- Climate diagnostics
- Lake level predictions
- Paleo context

Future directions:

- Enhance reconstruction skill
- Enhance length

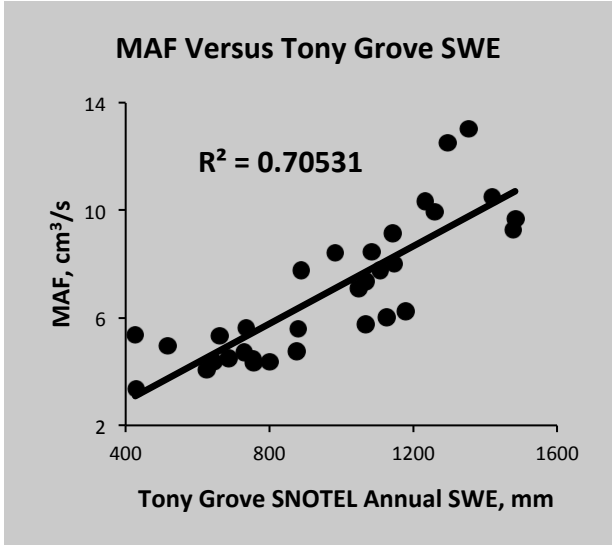
The Logan River

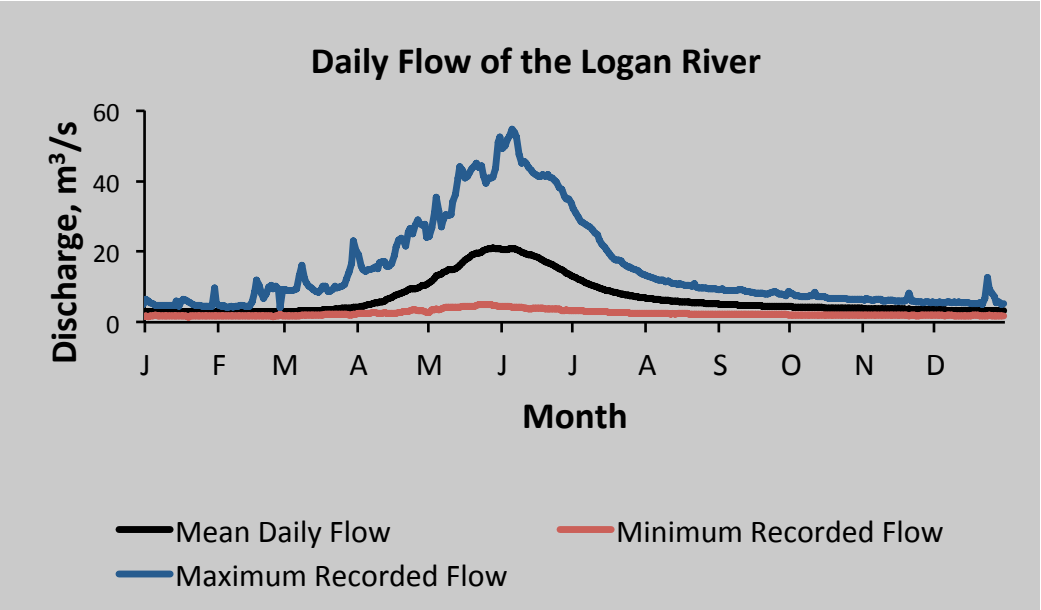
Research Objectives

- Update an existing Douglas-fir chronology on Naomi Peak, Bear River Range, Utah (Woodhouse, 1989)
- Develop 6 moisture-sensitive chronologies in northern Utah
- Reconstruct Logan River streamflow

Logan River Basin

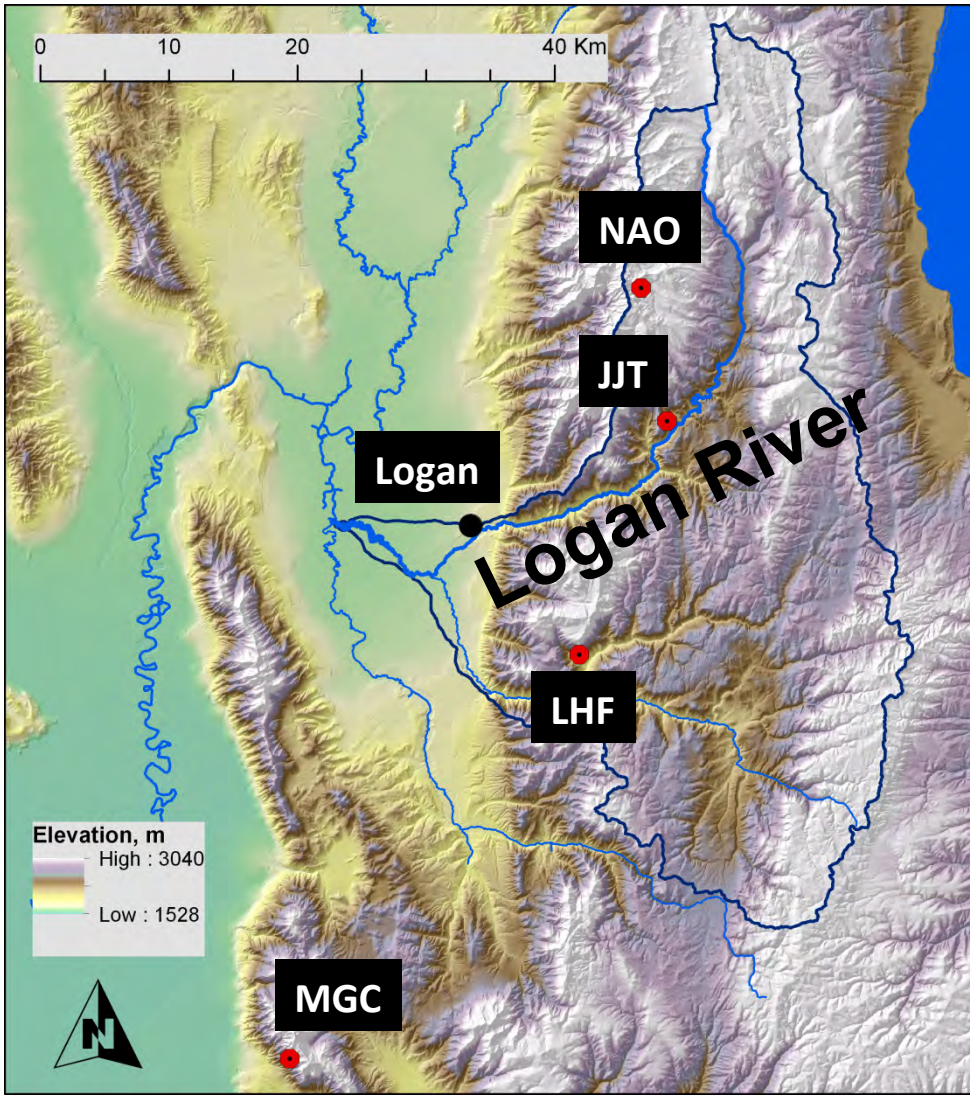
- Bear River Range, Utah
- Area: 2288 km^2
- Relief: 1694m
- Uses
  - Irrigation
  - Hydropower
  - Recreation
  - Ground water recharge for drinking water



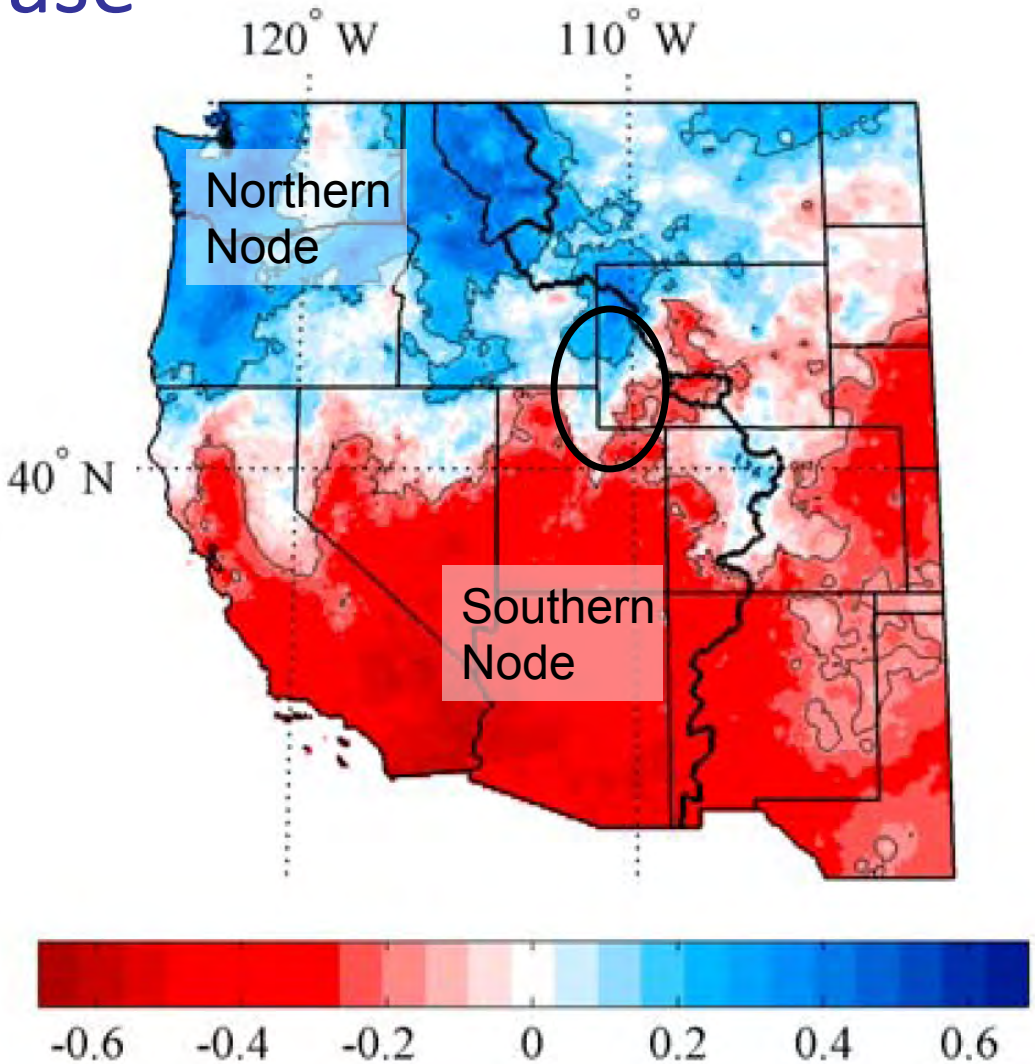


Data

- Logan River flow
  - USGS Gage 10109001
- New chronologies
  - Douglas-fir: NAO, JJT, MGC
  - Limber Pine: MGC
  - Rocky Mountain Juniper: LHF, JJT

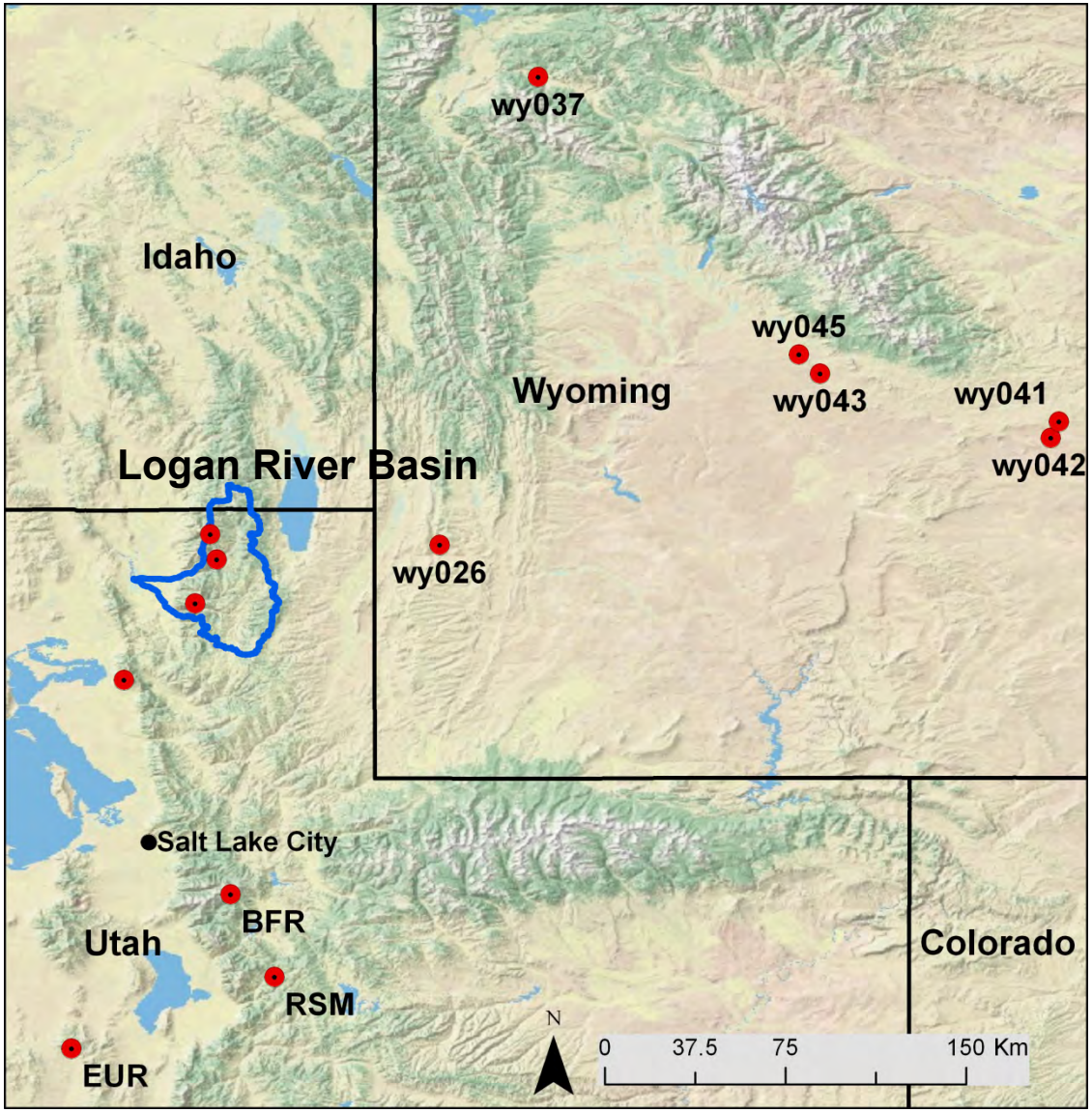


ENSO Climatology – Northern UT, little correlation to ENSO Phase



(Wise, 2010)

Regional Chronologies



- Regional climate
- Look for best flow predictors

Chronologies

Chronology	Common Name	Oldest Ring (AD)	Elevation, m	Collector
LHF-RMJ	Rocky Mountain Juniper	1562	1980	This study
NAO-DF	Douglas-fir	1274	2730	This study
JJT-DF	Douglas-fir	1511	2100	This study
MGC-LP	Limber Pine	1017	2730	This study
JJT-RMJ	Rocky Mountain Juniper	1227	2100	This study
RSM-TNP	Two needle pinyon pine	1694	2130	Bekker, unpublished
EUR-SNP	Single needle pinyon pine	1584	2070	Bekker, unpublished
BFR-DF	Douglas-fir	1178	3000	Bekker, unpublished
BFR-LP	Limber Pine	351	3000	Bekker, unpublished
wy026-LP	Limber Pine	1480	2225	Cook, et al., 1998
wy037-LP	Limber Pine	1315	2300	Wise, 2010
wy041-LP	Limber Pine	1017	2730	Pederson et al., 2011
wy042-LP	Limber Pine	1200	2430	Pederson et al., 2011
wy043-DF	Douglas-fir	1576	2430	Pederson et al., 2011
wy045-DF	Douglas-fir	1507	2430	Pederson et al., 2011

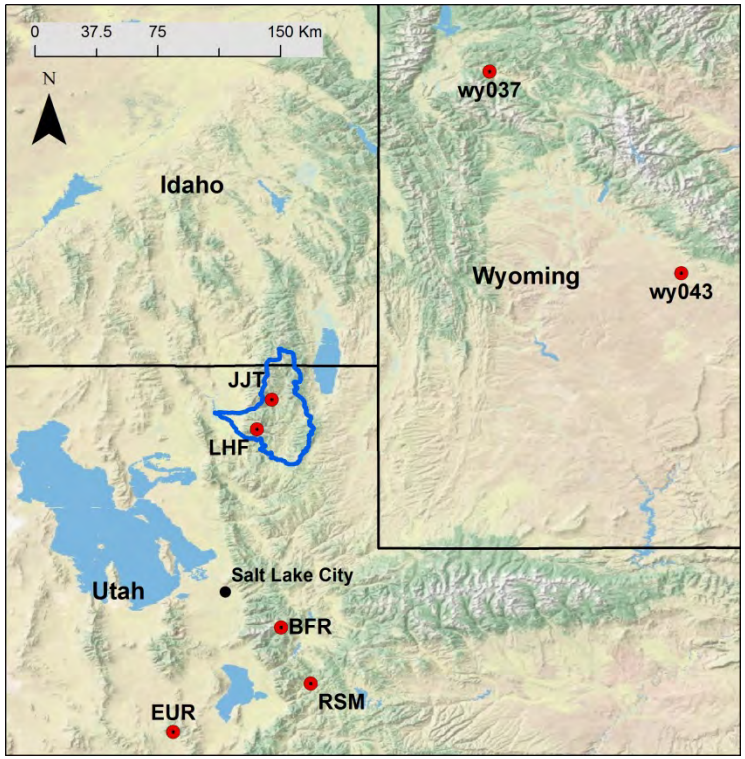
Chronologies and their lags considered for modeling

Stepwise Linear Models

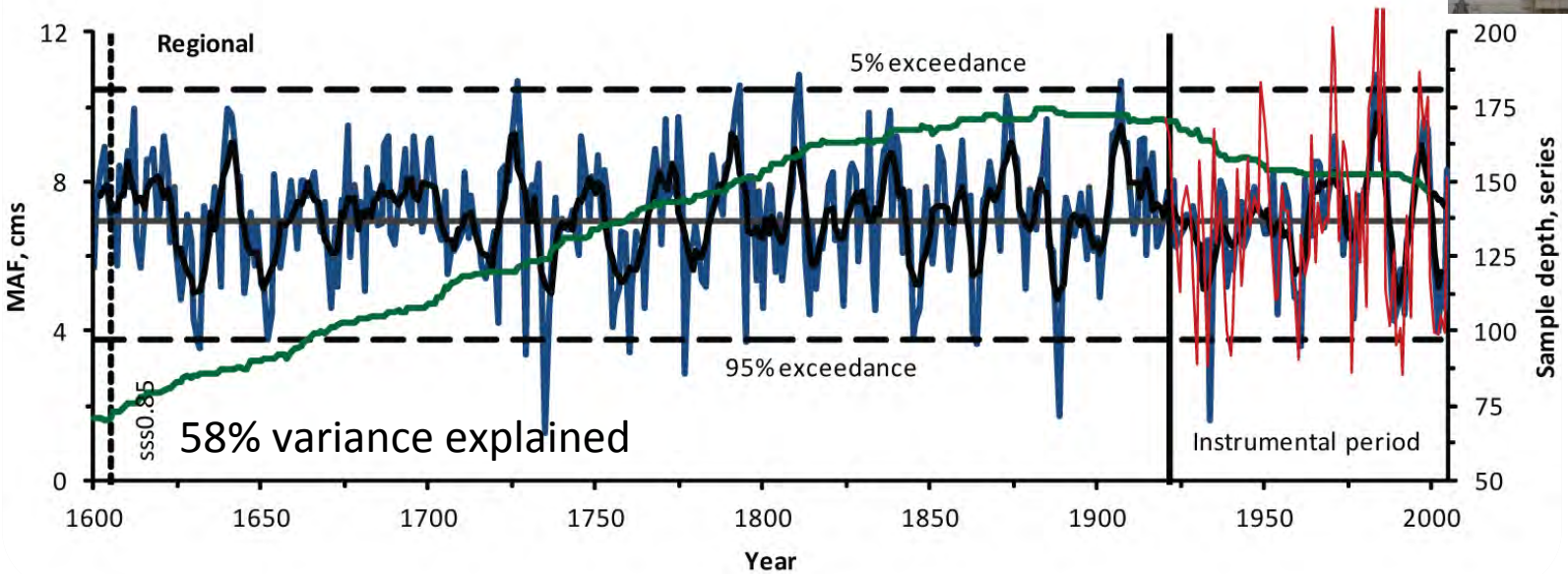
Two Reconstructions

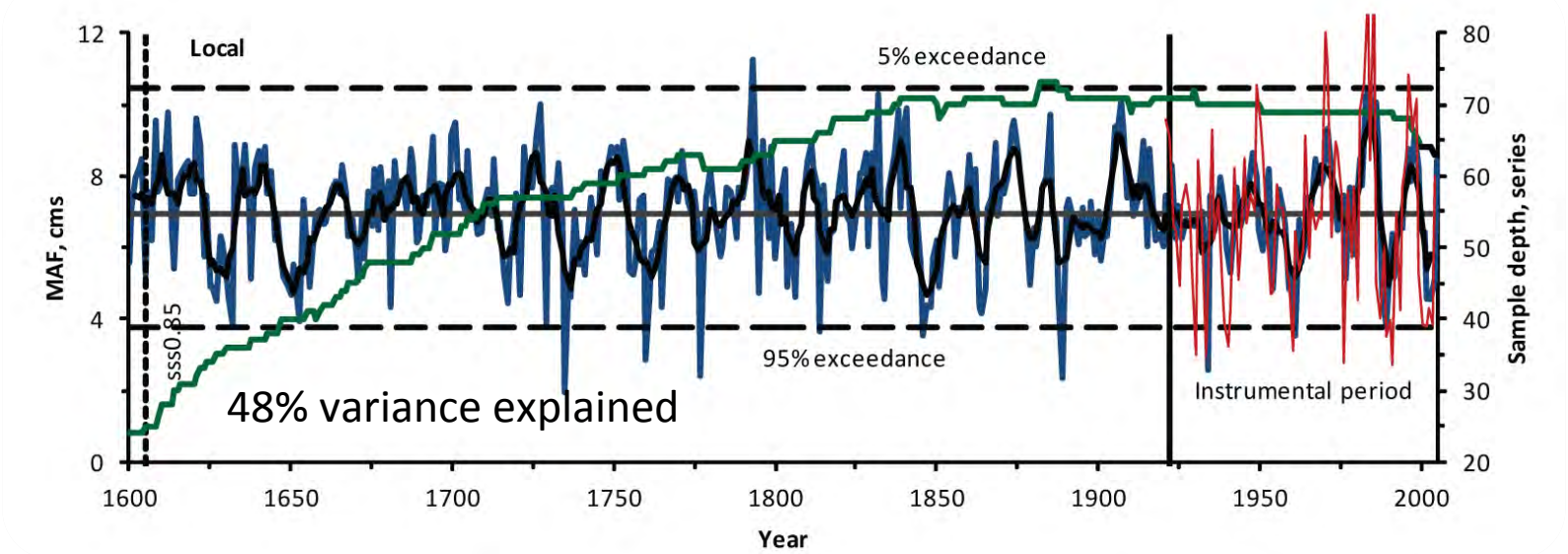
- Local: within-basin predictors
- Regional: all screened predictors

	Local 1674 -2010	Regional 1600 - 2004
1	JJT-RMJ	JJT-RMJ
2	LHF-RMJ	LHF-RMJ
3		EUR-SNP
4		RSM-TNP
5		wy043-DF
6		wy043-DF -1yr
7		JJT-DF +1yr

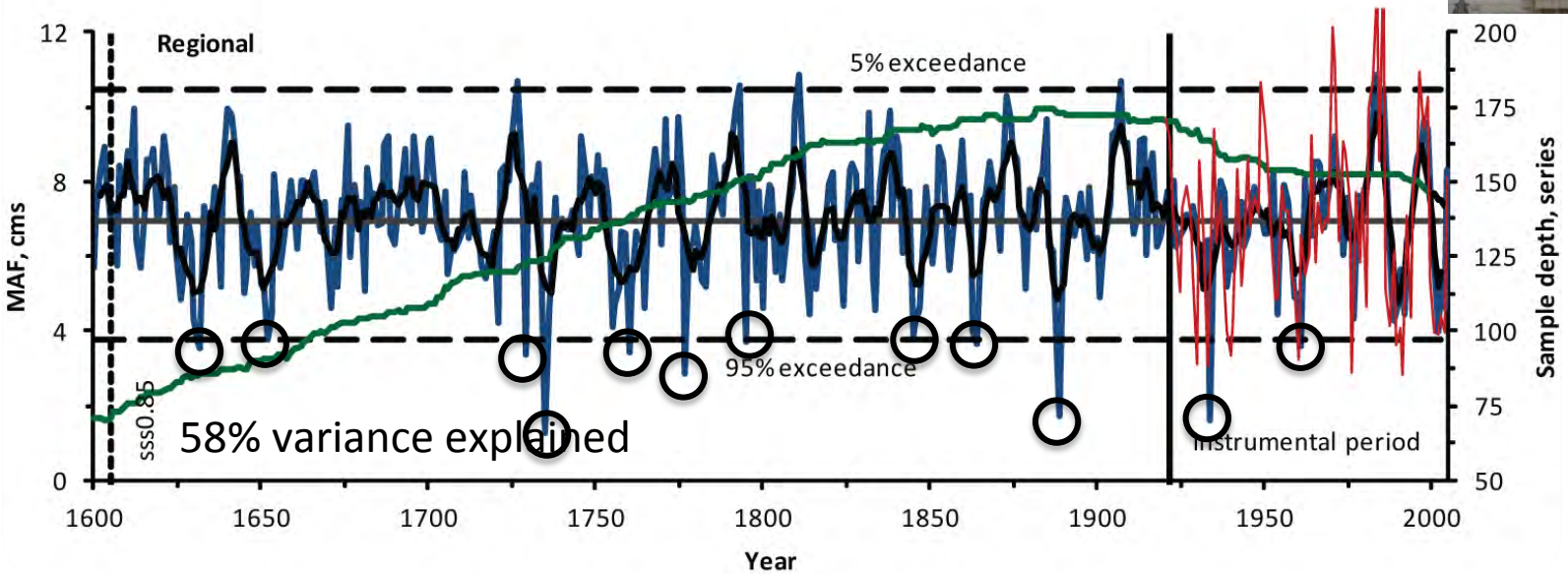


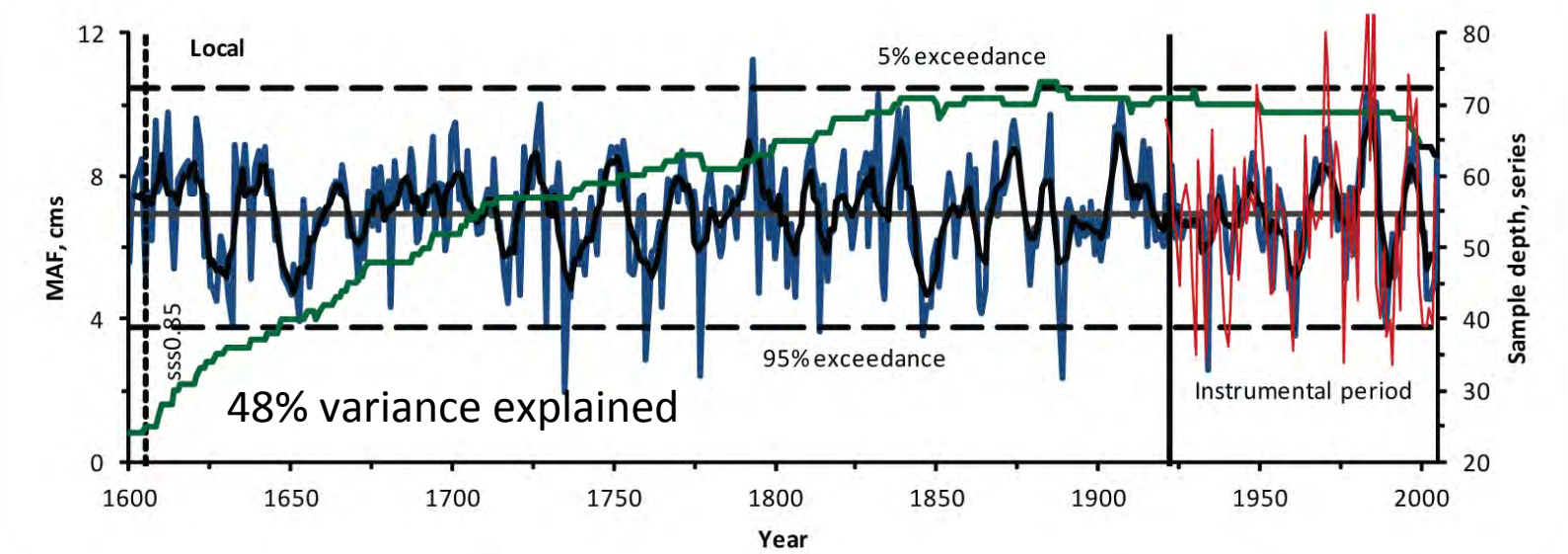
Logan River Reconstructed Mean Annual Flow





Logan River Reconstructed Mean Annual Flow

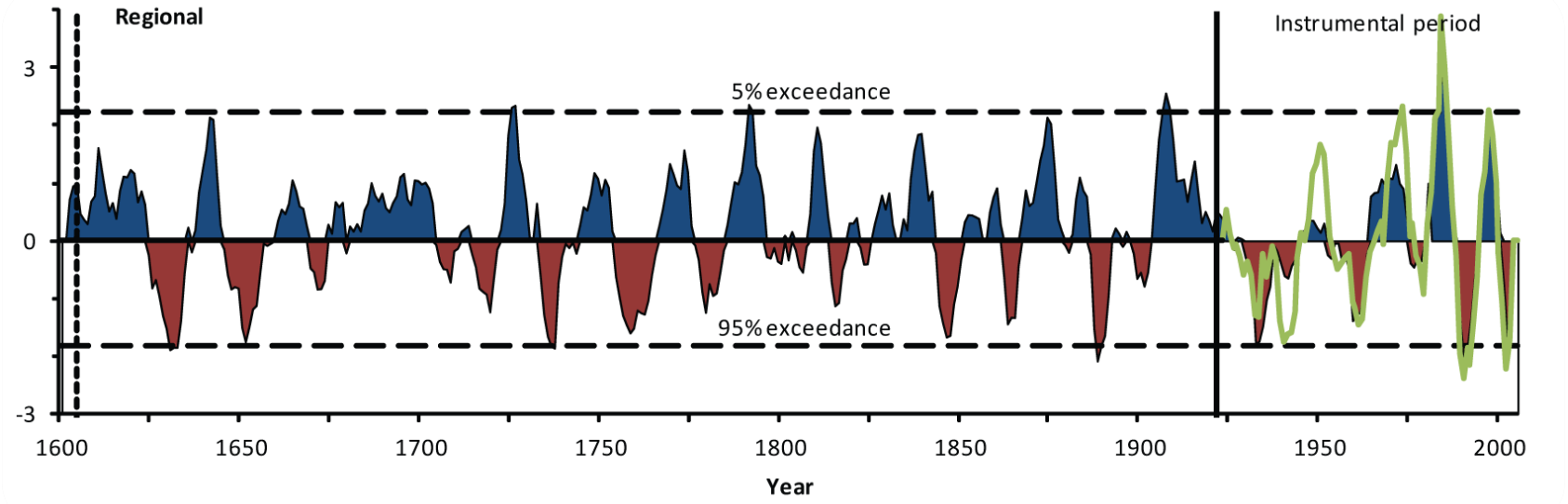


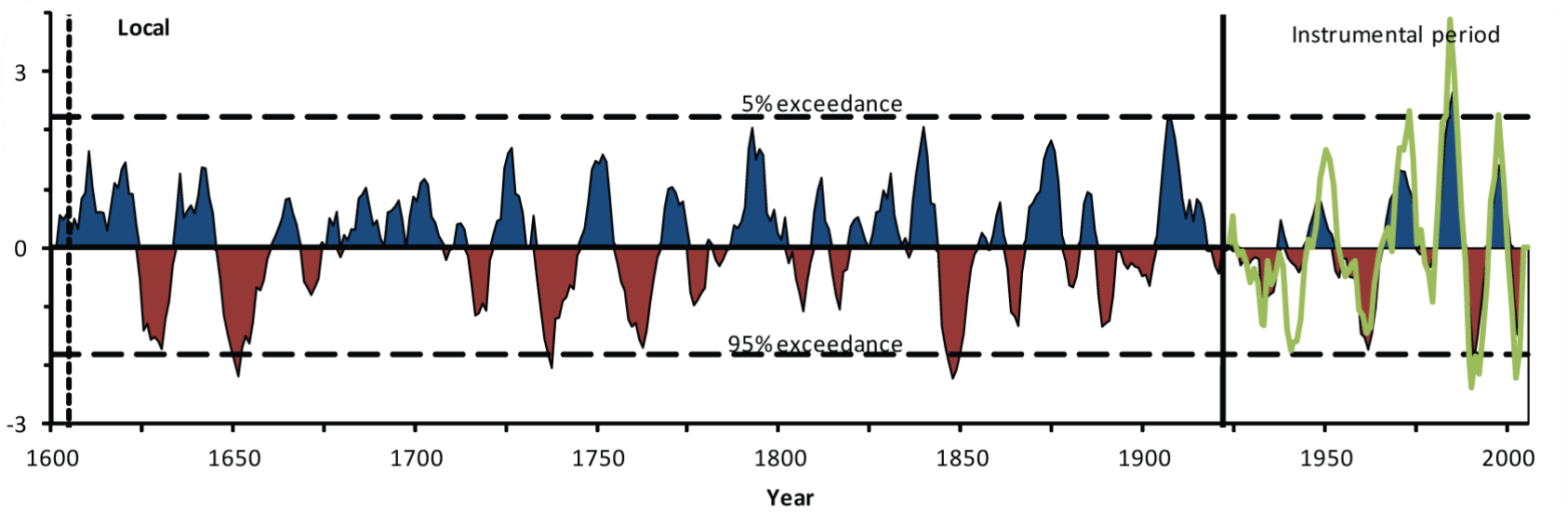


Periods of low flow (below 95% exceedance)

Driest years		Driest periods (5-yr av data)	
Year	maf, cms	Period	maf, cms
1735	**1.25**	**1988 - 1992**	**4.81**
1934	**1.58**	**1886 - 1890**	**4.81**
1889	**1.72**	**1628 - 1632**	**5.01**
1777	**2.85**	**1735 - 1739**	**5.04**
1888	**3.08**	**1630 - 1634**	**5.05**
1729	**3.38**	**1629 - 1633**	**5.05**
1760	**3.40**		
1632	**3.51**		
1961	**3.60**		
1864	**3.66**		

Logan River Mean Annual Flow – 5yr average Departures





Questions?